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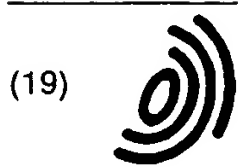
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(11) EP 0 586 373 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
12.03.1997 Bulletin 1997/11

(51) Int Cl.⁶: C09K 19/00, G03C 5/00,
G02F 1/13, B01D 61/42

(21) Application number: 91911607.9

(86) International application number:
PCT/US91/03759

(22) Date of filing: 30.05.1991

(87) International publication number:
WO 92/21733 (10.12.1992 Gazette 1992/31)

(54) METHODS OF FABRICATING DUAL ANODE, FLAT PANEL ELECTROPHORETIC DISPLAYS

VERFAHREN ZUR HERSTELLUNG ELEKTROPHORETISCHER FLACHANZEIGETAFELN MIT
DOPPELTER ANODE

PROCEDES DE FABRICATION DE DISPOSITIFS D'AFFICHAGE ELECTROPHORETIQUE A
PANNEAU PLAT ET A DEUX ANODES

(84) Designated Contracting States:
BE DE FR GB NL

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(43) Date of publication of application:
16.03.1994 Bulletin 1994/11

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(56) References cited:
EP-A- 0 396 247 US-A- 3 668 106
US-A- 4 203 106 US-A- 4 218 302
US-A- 4 522 472 US-A- 4 655 897
US-A- 4 680 103 US-A- 4 732 830
US-A- 4 772 820 US-A- 4 850 919
US-A- 5 006 212

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EP 0 586 373 B1

Description

Technical Field

The present invention relates to electrophoretic display apparatus in general and more particularly to methods for fabricating such displays having a dual anode structure.

Background Art

A dual anode, flat panel, electrophoretic display apparatus has been described in copending application Serial No. 345,825 filed May 1, 1989 entitled Dual Anode Flat Panel Electrophoretic Display Apparatus for Frank J. DiSanto and Denis A. Krusos, the inventors herein and assigned to Copytele Inc., the assignee herein. That application describes an electrophoretic display which has a grid cathode matrix arrangement consisting of a first plurality of conductive lines which are transverse to said first plurality. Located with respect to the grid and cathode are first and second anode structures. The first anode is removed from the second with the second anode overlying the grid lines of the display and insulated therefrom. The second anode is biased to implement typical hold and erase modes independent of the first anode and the display structure as indicated in the application exhibits many advantages when compared with prior art displays.

The electrophoretic display (EPID) is well known and there exist many patents and articles in the prior art which describe operation and characteristics as well as describing methods of fabricating such displays. The following patents are illustrative of prior art devices and approaches. These patents issued in the name of Frank J. DiSanto and Denis A. Krusos, the inventors herein. Apart from the patents to be described below, there are of course many references which were cited in the prosecution of these patents as well as additional references which were cited in the background of these patents. Many of the techniques and methods of fabricating such displays are disclosed in the patents that follow, as well as in the additional references as indicated.

U.S. Patent 4,655,897 issued on April 7, 1987 entitled Electrophoretic Display Panels and Associated Methods describes a typical electrophoretic display apparatus utilizing an X-Y matrix consisting of grid and cathode lines which are insulated one from the other and which are associated with an anode electrode. The space between the grid and cathode lines and the anode electrode is filled with an electrophoretic dispersion. The patent describes techniques for making such displays as well as suitable dispersions and materials for use with such displays.

U.S. Patent No. 4,732,830 issued on March 22, 1988 entitled Electrophoretic Display Panels and Associated Methods describes methods for making electrophoretic displays as well as describing display construc-

tion and operation.

U.S. Patent No. 4,742,345 issued on May 3, 1988 entitled Electrophoretic Display Panel Apparatus and Methods Therefore describes improved electrophoretic display panels exhibiting improved alignment and contrast as well as describing circuitry for use with such a display and methods for fabricating such a display.

U.S. Patent No. 4,746,917 issued on May 24, 1988 entitled Method and Apparatus for Operating Electrophoretic Displays Between a Display and a Non-Display Mode describes various biasing techniques for operating electrophoretic displays to provide writing, erasing as well as operating the display during a display and non-display mode.

U.S. Patent No. 4,722,820 issued on September 20, 1988 entitled Monolithic Flat Panel Display Apparatus describes methods and apparatus for fabricating flat panel displays employing electrophoretic principles as well structures to enable such displays to be biased and driven by additional circuitry.

Thus, as one can see, an important consideration of the prior art is to provide an improved display with increased contrast, faster operating time, and more reliable performance. As indicated in the above-noted copending application, a particularly disturbing problem which occurs in electrophoretic displays results in the appearance of a bright "flash" emanating from the display during the ERASE mode. This "flash" while occurring over a relatively short period is perfectly visible. The "flash" appears disturbing to many individuals who view the display and is caused by the following phenomenon. For proper operation of the electrophoretic display, the amount of pigment in the suspension is considerably greater than the pigment required to give a suitable background when the panel is in a HOLD condition. The term HOLD is well known in the art, and the electrophoretic panel is placed in a HOLD condition prior to writing the display. In this manner the HOLD condition is achieved when the anode is at a high positive voltage, the grid is at a low voltage, and the cathode is at a high voltage.

Typically, the anode would be at a voltage for example of 200 volts with the grid at a lower voltage as for example -12 volts with the cathode at a high voltage which would be +15 volts. With these voltages on the typical prior art electrophoretic display, the display is in the so-called HOLD condition. This HOLD condition is implemented prior to the WRITE mode during which mode new information is written into the display. The excess pigment during the HOLD condition is at the surface of the anode which is at the highest potential with respect to any other of the electrodes. To ERASE the display, the anode is made negative and all the pigment leaves the anode and is at the surface of the grid and cathode. During ERASE, the anode, for example, would be placed at -200 volts. Hence, during the ERASE mode, all the pigment leaves the anode and is now at the surface of the grid and cathode accordingly. Th

cathode side of the flat display during the ERASE mode is considerably brighter than it is during the HOLD causing a bright "flash" to appear on the display even when the ERASE time is extremely short.

The "flash" occurs between frames and may exist every 20 to 30 milliseconds caused by the change in brightness between the HOLD and the ERASE mode. It is, of course, desirable to eliminate this bright "flash" so that the display appears more uniform and stable.

Hence, the above-noted copending application describes the addition of a second anode which is interposed between the original anode of the electrophoretic display and the cathode-to-grid matrix. The second anode aides in preventing this flash by allowing the pigment to be selectively controlled.

This present application describes methods for fabricating a dual-anode display. The methods to be described shows a second anode or an additional anode which in one embodiment is designed to be parallel with the grid structure and in another embodiment is transverse or perpendicular to the grid structure. These methods include the selective deposition of different materials such as metals and insulators together with the use of selective etches in order to achieve the desired results.

Disclosure of the Invention

A method of completing fabrication of an electrophoretic display after a plurality of cathode conductor lines indicative of an X matrix have been formed on a planar glass sheet, comprising the steps of coating the cathode conductor lines with a first insulating layer of photoresist, coating the first insulating layer with a first layer of silicon dioxide, coating a first layer of metal on said layer of silicon dioxide, coating said first layer of metal with a second layer of photoresist, coating said second layer of photoresist with a second layer of silicon dioxide, coating said second layer of silicon dioxide with a second layer of metal capable of being etched by a different etchant than said first, coating said second layer of metal with a third layer of metal capable of being etched by a different etchant from said first and second layer of metal, coating said third layer of metal with a fourth layer of metal capable of being etched by a different etchant than said first, second and third layers of metal, coating said fourth layer of metal with a third layer of photoresist, treating said third layer of photoresist to photolithographically form a matrix of lines transverse to said cathode conductor lines and thereafter selectively etching each layer of material until channels separate each of the lines of said matrix wherein there are first and second metal structures insulated from each other and from the cathode structure, coating the treated structure with a layer of silicon dioxide, removing both said layer of silicon dioxide and said fourth metal layer.

The present invention further includes a method for fabricating an electrophoretic display of the type having

an X-Y matrix for grid and cathode operation, comprising the steps of depositing a first thin layer of a conductive metal on a carrier plate of glass, etching said layer to form a line pattern indicative of an X cathode matrix, depositing a first insulating layer of a photoresist resin on said X cathode matrix, depositing a first layer of silicon dioxide on said first layer of photoresist resin, depositing a second layer of a conductive metal on said layer of silicon dioxide, depositing a second insulating layer of a photoresist resin on said second metal layer, exposing said second layer of photoresist with a Y grid matrix mask, developing said photoresist according to said Y grid mask, etching said second layer of said conductive metal to form said Y grid matrix, removing the remainder of said second layer of photoresist, etching said layer of silicon dioxide with said etched second layer of conductive metal serving as a mask, depositing a third layer of photoresist resin on said etched second layer, depositing a second layer of silicon dioxide on said third layer of photoresist, depositing a first anode metal layer on said layer of silicon dioxide, depositing a second different anode metal layer on said first anode metal layer, depositing a fourth layer of a photoresist resin on said second different metal layer, treating said fourth layer of photoresist to photolithographically form an anode matrix of lines parallel to said Y grid matrix and perpendicular to said X cathode matrix, etching said first and second anode layers and covering said structure with a thin layer of silicon dioxide and etching away said second layer of anode metal leaving said first anode layer to provide an additional matrix designated as an anode matrix for said display.

Brief Description of the Drawings

Fig. 1 is a partial cross-sectional view showing an electrophoretic display useful in describing certain steps in the fabrication of such a display;

Fig. 2 is a cross-sectional view depicting an additional step in the fabrication of such a display;

Fig. 3 is a top plan view of an electrophoretic display fabricated according to a different method according to this invention; and

Fig. 4 is a cross-sectional view of the display of Fig. 3

Best Mode for Carrying out The Invention

Referring to FIG. 1, there is shown a cross-sectional view of an electrophoretic display 10 constructed according to the teachings of this invention. It is immediately noted that the cross-sectional view of the display of FIG. 1 includes structure resulting from certain of the processing steps which are not complete.

It is believed that the configuration shown in FIG. 1 is necessary in order to fully understand the invention. The unique part of this particular display is the configuration as well as the method of producing the second or

additional anode. The additional anode appears between the cathode 12 and the remote anode which is a conventional anode designated by reference numeral 28 in FIG. 2.

As seen from FIG. 2, the remote anode 28 is deposited upon a layer of glass 29. The remote anode 28 for example may be an extremely thin layer of indium-tin-oxide (ITO) which is deposited upon the layer of glass 29.

As one will further understand, the electrophoretic display is described in many of the prior patents as indicated above, and has a viewing area which includes a bottom glass sheet 11. Disposed upon sheet 11 are a plurality of cathode lines 12. These cathode lines are directed in a horizontal or vertical direction and are parallel to one another to form a matrix or grid of lines. A cross matrix, which is perpendicular to the cathode lines, consists of a series of parallel metal grid lines 15. These metal grid lines exist in prior art electrophoretic displays. The grid lines are separated from the cathode by means of an insulator material. This may be a dual layer of insulator material. A first layer consists of an insulator 13 which for example is a photoresist material such as FSC-L or FSC-M which essentially are novolac resins or phenolic resins. These resins are available as photoresist materials from a company called Shipley Products.

As seen in FIG. 1 and as will be further explained, the layer of photoresist or insulator 13 has deposited on the surface thereof a layer of silicon dioxide (SiO_2) 14. The layer of silicon dioxide is deposited on the layer of photoresist and thereafter a layer of metal 15 which constitutes the grid electrode is deposited upon the layer of silicon dioxide. In the construction shown in FIG. 1 and as will be further explained, deposited on top of the grid layer 15 is an additional layer 16 of photoresist which has deposited thereon an additional layer 17 of silicon dioxide. On top of the layer of silicon dioxide is a first layer of metal 18, a second layer of metal 19 and a third layer of metal 20. It is important that metal layers 15, 18, 19 and 20 be fabricated from metal materials which are capable of being etched by different selective etchants.

For example, such metal materials may comprise gold, aluminum, titanium-tungsten alloy, zirconium as well as chrome. In this particular instance, the grid electrode layer 15 may be fabricated from chrome while the metal layers 18 and 19 may be an alloy of chrome and aluminum which will etch for example, by means of a different etchant other than the chrome layer. The above description indicates the deposition of separate layers which is in fact the case. The structure shown in FIG. 1 results after the steps of selective etching have been implemented as will be explained.

As one will see, the second anode which will include metal layers 18 and 19, and the grid structure as 15 are perpendicular to the cathode lines 12 and essentially the grid electrode 15 is parallel to and in line with the second anode conductor lines. Before describing the exact

process by which the structure of FIG. 1 is fabricated, a few comments will be made concerning the operation of the same. As one can understand, the grid lines 15 which are separated from the cathode lines by means of the photoresist layer 13, and the layer of silicon dioxide 14 are disposed transverse to the cathode lines 12 and spatially intersect each cathode line to provide an X-Y matrix arrangement whereby a typical pixel area is accessed by addressing a grid and cathode line thereby providing a desired potential at the intersection between the two lines. This potential causes the migration of electrophoretic particles which are suspended in the electrophoretic suspension 30 and which particles migrate from the grid and cathode structure to the anode 28 (FIG. 2). The anode 28 is a very thin layer of metal as ITO deposited on a planar glass member 29 according to prior art teachings.

Typically, the thickness of the insulated areas as 13 and 16 are approximately 3 microns with the layers of silicon dioxide as for example, layers 14 and 17 being about 2000 Angstroms. In the structure shown in FIG. 1 the local anode which will be further described is of the same configuration as the grid structure. A local anode metal conductor line which eventually comprises metals 18 and 19 for example is separated from the grid line 15 by the insulating layer 16 and the layer of silicon dioxide 17. Thus, there are as many anode lines as there are grid lines. Each segment of the anode can have the same exact configuration as the associated grid segment. It is understood that the grid line can comprise a fine configuration as known in the prior art and such a configuration may or may not be used for the local anode lines. Hence, the grid format may be two or more lines with the anode line being a single line or a duplicate line configuration.

For example, U.S. Patent No. 4,742,345 describes a grid structure fabricated with respect to the cathode structure in a fine configuration. Thus, one can utilize such a configuration to form the grid structure and therefore the anode structure. The advantages of such arrangements have been fully described in U.S. Patent No. 4,742,345. In this manner, and as explained in the above-noted copending application, it is further seen that the local anode structure may consist of a plurality of parallel lines each of which is associated with a grid line, and with each of the parallel lines being dimensioned and congruent with each of the associated grid lines as 15. The biasing of the various electrodes as shown in FIG. 1 has also been explained in detail in the above-noted copending application. Thus, the biasing of each electrode in HOLD, ERASE and WRITE modes has been explained as well as the movement of the pigment and the advantages of the display.

The methods of fabricating a dual anode display to be described herein employ alternate approaches. The cross-sectional view depicted in FIG. 1 shows certain steps in the fabrication of the display. As indicated, numeral 11 references a planar glass sheet. The glass

sheet or plate 11 acts to provide a port through which a viewer of the display may discern image information set forth therein. The glass plate 11 is preferably coated with an extremely thin layer of indium-tin-oxide (ITO) as available as described in many of the above-noted patents. The layer of ITO 12 is relatively thin approximately in the range of 300 Angstroms in thickness so that the glass plate 11 retains its relative transparent characteristics. The cathode lines 12 are etched from the ITO layer which is overcoated on the glass plate 11. This may be achieved as will be readily appreciated by those of ordinary skill in the art through conventional photo-etching or engraving techniques. Hence, a physical mask bearing representations of the cathode conductors as well as associated contact pads is employed to form an image of the plurality of cathode conductors 12 on the glass plate 11 and thereafter portions of the ITO coating not corresponding to the image are removed. More particularly, the glass plate 11 bearing the ITO layer may be initially overcoated with a photoresistive layer of any conventional form and thereafter masked having a conductive pattern associated with the plurality of cathode lines 12 displaced on the photoresistive layer. The glass plate is then exposed to ultraviolet light through the mask and developed.

The pattern remains and eventually is transformed into a plurality of cathode lines. Hence, the cathode is conventionally fabricated by means of prior art techniques leaving the glass layer 11 having on the surface thereof a plurality of cathode lines or column lines 12. One can gain further information regarding the construction utilizing the mask and related procedures by reference to US Patent No. 4,742,345.

After this step, the entire structure is coated with an insulating layer of FSC-L or FSC-M. There are photoresist materials as above indicated and are novalac or phenolic resins. The insulating layers 13 are spun onto the surface of the glass plate having the cathode structure 12. Contrary to FIG 1 an entire layer or coating 13 as shown by the line 13 is deposited upon the surface of the glass plate 11 having the cathode pattern 12 impressed thereon. The entire surface is thus covered. Next a thin layer of silicon dioxide 14 is placed on the entire surface of the insulative layer 13. Again, this is done as a single coat. The layer of silicon dioxide is extremely thin and may be, for example, of a magnitude of 2000 Angstroms with the layer of photoresist being about 3 to 5 microns. After depositing the layer of silicon dioxide 14, a first layer of metal 15 such as aluminum is then deposited upon the silicon dioxide layer. The aluminum can be deposited by many well known techniques such as vapor deposition and so on. After depositing the layer of aluminum, another layer 16 of FSC-L or FSC-M is deposited on the aluminum layer. This layer 16 then has deposited on the surface another layer of silicon dioxide. Then three different metals are deposited on the layer of silicon dioxide. There is first deposited a layer of metal 18 followed by a layer of metal 19,

followed by a layer of metal 20. Each of these metals must not be capable of being etched using the same etchant, or capable of being etched by the same etchant as used for the metal deposited on the first layer of FSC-L or FSC-M as layer 15 which is the grid layer. In any event, selective etchants employed for different metals are well known in the art as well as the different metals which are capable of being etched by using different etches. After the last layer of metal 20 is deposited, a coating of photoresist 31 is then spun onto the uppermost layer 20. The photoresist layer 31 is shown as a full layer as compared to the column structures depicted for the remaining portions of the grid. It is understood that the lines which are directed through each of the aluminum layers indicate that total laminate is formed prior to the etchant steps.

The photoresist layer 31 is then exposed to a mask which is essentially similar in design to the grid mask and consists of a plurality of parallel lines and is placed transverse to the cathode structures. Thus the mask is used to expose the top photoresist layer 31 in order to eventually provide the column areas as indicated by reference numerals 33, 34 and 35. The photoresist layer 31 is then developed whereby the uppermost layer of the metal 20 is etched using an appropriate etchant for that layer and thus forming a first portion of the channel 36. The next two layers of metal 18 and 19 are etched using appropriate etchants which selectively attack that layer thus forming the further channels 37 and 38. The layer of silicon dioxide 17 is plasma etched using the metal layers as 18, 19 and 20 as a mask, thus forming the next portion of the channel or depression 39. The insulating layer 16 is then plasma etched completely down to the first layer of metal 15 thus forming the next portion of the channel 40. Then the first layer of metal 15 is then etched using an appropriate etchant for that layer forming the next portion of the channel 41. The layer of silicon dioxide between the layer 15 and the insulating layer 13 between the first layer of metal 15 and the cathode 12 is plasma etched.

Referring to FIG. 2, after the above noted procedure, one now has the upstanding vertical columns as shown separated by channels. Next the entire structure in FIG. 1 coated with a layer of silicon dioxide which layer is applied to the entire structure. Then using an appropriate etchant, the upper most layer of metal is removed thereby removing the silicon dioxide covering the metal layer 20 as well the metal layer while leaving the metal layer 19 exposed. The side surfaces as well as the spacing between the side surfaces are all covered with an extremely thin layer of silicon dioxide 40. Then utilizing appropriate insulating spacers the anode which includes glass plate 29 and the remote anode structure 28 is attached to the treated structure. At the same time leads are made available not only for the second anode which consists now of metal layers 18 and 19 but also for the original anode is ITO layer 28. Thus as one can understand, the cell is now ready for accepting driver

chips which are cemented and bonded to the glass plate in the usual manner and as for example described in US Patent 4,772,820 as indicated above.

It has been determined that by providing a layer of silicon dioxide on the peripheral walls of each of the additional grid and second anode structure, one achieves extremely reliable performance in regard to the device.

Referring to FIG. 3 there is shown a top plan view of a partial section of an electrophoretic display made according to a second implementation. The top plan view of FIG. 3 shows the structure prior to a final coating of silicon dioxide. Essentially, as seen from FIG. 3, the cathode lines which are deposited as described above, are designated by references numerals 41, 42 and 43. Disposed on top of the cathode lines and insulate therefrom are separate grid line structures as 50, 51 and 53. The three line structures 50, 51 and 53 represent for example, a single grid line. Aligned parallel with the cathodes are the second anode lines designated by reference numerals 54 and 55 as associated with the cathode line 44. As will be explained the grid lines as 50, 51 and 53 are fabricated from a different metal than the second anode lines 54 and 55 constitute two lines for each cathode but may be more than two. The grid lines constitute three lines as 50, 51 and 53. The implementation of the display as well as the fabrication of the display can be best described by referring both to FIG. 3 and FIG. 4. As seen in FIG. 4, the bottom layer 45 which consists of glass has deposited thereon the ITO cathode layers as 41, 42, 43 and 44. The cathode matrix is fabricated as described above and is formed from a single layer of ITO which covers the entire glass sheet which ITO is then suitably etched or engraved to produce individual parallel cathode lines as 41, 42, 43 and 44. Thus the construction of the cathode is implemented utilizing the usual mask and procedures as described above. The next thing that occurs is that a complete layer 60 of FSC-L or FSC-M is deposited on and coats the entire cathode structure. Then a layer of silicon dioxide 61 is vapor deposited on or oxidized on the insulating layer 60. The next step in the procedure is to then deposit a layer of metal such as chrome which is layer 62 and deposited on the silicon dioxide layer 61. This layer of metal 62 constitutes the grid structure. A layer of photoresist is then spun on the metal layer 62. This layer is not shown. In any event, the layer of photoresist is then exposed by the grid mask in the usual manner and hence, one produces the grid line pattern as for example, 50, 51 and 53 on the photoresist layer which is spun on the metal layer 62. The grid mask is used to expose the photoresist in the usual manner. After developing the photoresist, the metal is etched using a suitable etchant. As indicated, the metal layer 62 is chrome and one would then employ a chrome etchant. The photoresist layer is now stripped off in an appropriate solvent. The layer of silicon dioxide 61 is now plasma etched with the etched metal 62 serving as a mask. This therefore develops the appropriate grid structure. Next an insulating layer of

FSC-L or FSC-M is deposited on the patterned metal layer and designated by referenced numeral 65. The insulative layer 65 is now coated with a thin layer of silicon dioxide 64. Deposited on top of the layer of silicon dioxide 64 is a second metal layer 63 which may be of a different material than the first layer. This layer 63 consists of two metal layers with a first layer of metal closest to the silicon dioxide layer 64 being the same as the first layer of metal 62. Each layer is capable of being etched by a different etchant. A layer of photoresist is now spun on the uppermost metal layer and completely covers the same.

It is understood that while the layers 63, 64 and 65 are shown as upstanding columns, it is expressly understood that these are distinct layers. After a top layer of photoresist is spun on the uppermost metal layer, a mask including lines similar to but not necessarily the same as the grid is placed on a photoresist such that the pattern is parallel to the cathode as 41 and 42 and perpendicular to the grid as grid line 62. After developing the photoresist, both metal layers are etched using appropriate etchants. The silicon dioxide layer 64 is plasma etched using the metal layers as composite layer 63 as a mask. Both the first and second layers of FSC-L or FSC-M are plasma etched down to the cathode as seen in the top view. Using an appropriate solvent, any residue from the plasma etching is removed. Then a coating of silicon dioxide is applied to the entire structure. Again, using an appropriate etchant, the uppermost layer of metal is removed thereby removing the silicon dioxide covering the metal and leaving the second layer of metal exposed. Using appropriate insulator spacers the remote anode is attached to the structure making sure that a lead is made available for connecting to the anode. The second layer may be connected with all leads in parallel, with each lead individually driven or with leads being driven in groups. The cell is now ready for accepting driver chips cemented and bonded in the usual manner.

Claims

1. A method of completing fabrication of an electrophoretic display after a plurality of cathode conductor lines indicative of an X matrix have been formed on a planar glass sheet, comprising the steps of:

coating the cathode conductor lines with a first insulating layer of photoresist,
coating the first insulating layer with a first layer of silicon dioxide,
coating first layer of metal on said layer of silicon dioxide,
coating said first layer of metal with a second layer of photoresist,
coating said second layer of photoresist with a second layer of silicon dioxide,

- coating said second layer of silicon dioxide with a second layer of metal capable of being etched by a different etchant than said first, coating said second layer of metal with a third layer of metal capable of being etched by a different etchant from said first and second layer of metal, coating said third layer of metal with a fourth layer of metal capable of being etched by a different etchant than said first, second and third layers of metal, coating said fourth layer of metal with a third layer of photoresist, treating said third layer of photoresist to photolithographically form a matrix of lines transverse to said cathode conductor lines and thereafter selectively etching each layer of material until channels separate each of the lines of said matrix wherein there are first and second metal structures insulated from each other and from the cathode structure, coating the treated structure with a layer of silicon dioxide, removing both said layer of silicon dioxide and said fourth metal layer.
2. The method according to Claim 1 further including the step of placing an anode plate parallel to said anode, cathode and grid matrices.
 3. The method according to Claim 1, wherein the step of coating with an insulating layer of photoresist is coating with a phenolic resin.
 4. The method according to Claim 1, wherein said first metal is chrome.
 5. The method according to Claim 1, wherein said second metal is aluminium.
 6. The method according to Claim 1, wherein said third metal is an aluminium chrome alloy.
 7. The method according to Claim 1, wherein said fourth metal is an alloy of titanium and tungsten.
 8. The method according to Claim 1, wherein said layers of silicon dioxide are about 2000 Angstroms thick.
 9. The method according to Claim 1, wherein said layers of photoresist are between 3 to 5 microns thick.
 10. The method according to Claim 1, wherein selectively etching includes etching said layers of silicon dioxide and said layers of photoresist by plasma etching.

11. The method according to Claim 1, wherein the steps of coating with a photoresist insulating layer includes spinning said photoresist on said layer.
12. The method according to Claim 1, wherein the metal electrode structure indicative of the grid matrix comprises a plurality of grid lines with each line comprising at least two line members.
13. The method according to Claim 1, wherein one metal structure has lines parallel to the cathode lines, while the other metal structure has lines transverse to the cathode lines.
14. A method for fabricating an electrophoretic display of the type having an X-Y matrix for grid and cathode operation, comprising the steps of:

depositing a first thin layer of a conductive metal on a carrier plate of glass,
 etching said layer to form a line pattern indicative of an X cathode matrix,
 depositing a first insulating layer of a photoresist resin on said X cathode matrix,
 depositing a first layer of silicon dioxide on said first layer of photoresist resin,
 depositing a second layer of a conductive metal on said layer of silicon dioxide,
 depositing a second insulating layer of a photoresist resin on said second metal layer,
 exposing said second layer of photoresist with a Y grid matrix mask,
 developing said photoresist according to said Y grid mask,
 etching said second layer of said conductive metal to form said Y grid matrix,
 removing the remainder of said second layer of photoresist,
 etching said layer of silicon dioxide with said etched second layer of conductive metal serving as a mask,
 depositing a third layer of photoresist resin on said etched second layer,
 depositing a second layer of silicon dioxide on said third layer of photoresist,
 depositing a first anode metal layer on said layer of silicon dioxide,
 depositing a second different anode metal layer on said first anode metal layer,
 depositing a fourth layer of a photoresist resin on said second different metal layer,
 treating said fourth layer of photoresist to photolithographically form an anode matrix of lines parallel to said Y grid matrix and perpendicular to said X cathode matrix,
 etching said first and second anode layers, covering said structure with a thin layer of silicon dioxide and etching away said second layer

of anode metal leaving said first anode layer to provide an additional matrix designated as an anode matrix for said display.

15. The method according to Claim 14 further including the steps of placing an anode plate parallel to said anode, cathode and grid matrices. 5
16. The method according to Claim 14, wherein said first thin layer of a conductive metal is indium-tin oxide (ITO). 10
17. The method according to Claim 14, wherein said second layer of metal is chrome. 15
18. The method according to Claim 14, wherein said first anode metal layer is aluminum with said second anode metal layer being chrome.
19. The method according to Claim 14, wherein the step of depositing a photoresist resin on said X cathode matrix is spinning said resin on said X cathode matrix. 20
20. The method according to Claim 14 wherein the steps of etching said layer of silicon dioxide is plasma etching said layer. 25

Patentansprüche

1. Verfahren zur Fertigstellung eines elektrophoretischen Displays nach Bildung einer Vielheit von eine X-Matrix bezeichnenden Kathodenleiterzeilen auf einer ebenen Glasplatte, bestehend aus den folgenden Schritten: 30

Beschichten der Kathodenleiterzeilen mit einer ersten Isolierschicht aus Photoresist, 40

Beschichten der ersten Isolierschicht mit einer ersten Schicht aus Siliziumdioxid,

Aufbringen einer ersten Metallschicht auf besagter Siliziumdioxidschicht, 45

Beschichten besagter erster Metallschicht mit einer zweiten Schicht aus Photoresist,

Beschichten besagter zweiter Photoresistschicht mit einer zweiten Schicht aus Siliziumdioxid, 50

Beschichten besagter zweiter Siliziumdioxidschicht mit einer zweiten Metallschicht, die durch in ander s Ätzmittel als die rste geätzt werden kann, 55

Beschichten besagter zweiter Metallschicht mit einer dritten Metallschicht, die durch ein anderes Ätzmittel als die erste und die zweite Metallschicht geätzt werden kann,

Beschichten besagter dritter Metallschicht mit einer vierten Metallschicht, die durch ein anderes Ätzmittel als die erste, die zweite und die dritte Metallschicht geätzt werden kann,

Beschichten besagter vierter Metallschicht mit einer dritten Schicht aus Photoresist,

Behandeln besagter vierter Photoresistschicht zur photolithographischen Bildung einer Matrix von Zeilen quer zu besagten Kathodenleiterzeilen und danach selektives Ätzen der einzelnen Materialschichten, bis Kanäle alle Zeilen besagter Matrix trennen, wobei erste und zweite voneinander und von der Kathodenstruktur isolierte Metallstrukturen vorhanden sind,

Beschichten der behandelten Struktur mit einer Schicht aus Siliziumdioxid,

Entfernen besagter Siliziumdioxidschicht und besagter vierter Metallschicht.

2. Verfahren nach Anspruch 1, mit dem weiteren Schritt des Aufbringens einer Anodenplatte parallel zu besagten Anoden-, Kathoden- und Gittermatrizen.
3. Verfahren nach Anspruch 1, wobei der Schritt des Beschichtens mit einer Isolierschicht aus Photoresist ein Beschichten mit Phenolharz ist.
4. Verfahren nach Anspruch 1, wobei besagtes erstes Metall Chrom ist.
5. Verfahren nach Anspruch 1, wobei besagtes zweites Metall Aluminium ist.
6. Verfahren nach Anspruch 1, wobei besagtes drittes Metall eine Aluminium/Chrom-Legierung ist.
7. Verfahren nach Anspruch 1, wobei besagtes viertes Metall eine Legierung aus Titan und Wolfram ist.
8. Verfahren nach Anspruch 1, wobei besagte Siliziumdioxidschichten 2000 Ångström dick sind.
9. Verfahren nach Anspruch 1, wobei besagte Photoresistschichten 3 bis 5 Mikron dick sind.
10. Verfahren nach Anspruch 1, wobei das selektive Ätzen das Ätzen besagter Siliziumdioxidschichten und besagter Photoresistschichten im Plasmaätz-

verfahren umfaßt.

11. Verfahren nach Anspruch 1, wobei die Schritte des Beschichtens mit einer Isolierschicht aus Photoresist das Aufschleudern des Photoresists auf besagte Schicht umfassen. 5
12. Verfahren nach Anspruch 1, wobei die die Gittermatrix bezeichnende metallische Elektrodenstruktur aus einer Vielheit von Gitterzeilen besteht, die jeweils mindestens zwei Zeilenelemente aufweisen. 10
13. Verfahren nach Anspruch 1, wobei eine Metallstruktur Zeilen parallel zu den Kathodenzeilen hat, während die andere Metallstruktur Zeilen quer zu den Kathodenzeilen hat. 15
14. Verfahren zur Herstellung eines elektrophoretischen Displays der mit einer X-Y-Matrix für Gitter- und Kathodenbetrieb ausgestatteten Art, bestehend aus den folgenden Schritten: 20

Ablagern einer ersten dünnen Schicht aus einem leitfähigen Metall auf einer Trägerplatte aus Glas, 25

Ätzen besagter Schicht zur Bildung eines eine X-Kathodenmatrix bezeichnenden Zeilenmusters, 30

Ablagern einer ersten Isolierschicht aus Photoresistharz auf besagter X-Kathodenmatrix, 35

Ablagern einer ersten Schicht aus Siliziumdioxid auf besagter erster Photoresistschicht, 40

Ablagern einer zweiten Schicht aus einem leitfähigen Metall auf besagter Siliziumdioxidschicht, 45

Ablagern einer zweiten Isolierschicht aus Photoresistharz auf besagter zweiter Metallschicht, 50

Belichten besagter zweiter Photoresistschicht mit einer Y-Gittermatrixmaske, 55

Entwickeln des Photoresists entsprechend besagter Y-Gittermaske, 60

Ätzen besagter zweiter Schicht aus leitfähigem Metall zur Bildung besagter Y-Gittermatrix, 65

Entfernen des Restes besagter zweiter Photoresistschicht, 70

Ätzen besagter Siliziumdioxidschicht, wobei besagte zweite Schicht aus leitfähigem Metall als Maske dient, 75

Ablagern einer dritten Schicht aus Photoresistharz auf besagter geätzter zweiter Schicht, 80

Ablagern einer zweiten Schicht aus Siliziumdioxid auf besagter dritter Photoresistschicht, 85

Ablagern einer ersten Anodenmetallschicht auf besagter Siliziumdioxidschicht, 90

Ablagern einer zweiten unterschiedlichen Anodenmetallschicht auf besagter erster Anodenmetallschicht, 95

Ablagern einer vierten Schicht aus Photoresistharz auf besagter zweiter unterschiedlicher Metallschicht, 100

Behandeln besagter vierter Photoresistschicht zur photolithographischen Bildung einer Anodenmatrix von Zeilen, die parallel zu besagter Y-Gittermatrix und senkrecht zu besagter X-Kathodenmatrix verlaufen, 105

Ätzen besagter erster und zweiter Anodenschichten, 110

Abdecken besagter Struktur mit einer dünnen Schicht aus Siliziumdioxid und Wegätzen besagter zweiter Anodenmetallschicht unter Belassung besagter erster Anodenschicht zur Schaffung einer zusätzlichen Matrix, die als eine Anodenmatrix für besagtes Display bestimmt ist. 115

15. Verfahren nach Anspruch 14, mit den weiteren Schritten des Aufbringens einer Anodenplatte parallel zu besagten Anoden-, Kathoden- und Gittermatrizen. 120

16. Verfahren nach Anspruch 14, wobei besagte erste dünne Schicht aus leitfähigem Metall aus Indiumoxid (ITO) besteht. 125

17. Verfahren nach Anspruch 14, wobei besagte zweite Metallschicht aus Chrom besteht. 130

18. Verfahren nach Anspruch 14, wobei besagte erste Anodenmetallschicht aus Aluminium und besagte zweite Anodenmetallschicht aus Chrom besteht. 135

19. Verfahren nach Anspruch 14, wobei der Schritt des Ablagerns eines Photoresistharzes auf besagter X-Kathodenmatrix das Aufschleudern besagten Harzes auf besagte X-Kathodenmatrix ist. 140

20. Verfahren nach Anspruch 14, wobei die Schritte des Ätzens besagter Siliziumdioxidschicht das Plasmaätzen besagter Schicht sind. 145

Revendications

1. Une méthode pour achever la fabrication d'un afficheur électrophorétique après la formation d'une pluralité de lignes conductrices de cathode représentative d'une matrice en X sur une feuille de verre plane, comprenant les étapes de:

revêtement des lignes conductrices en cathode avec une première couche isolante de photorésistance,

revêtement de la première couche isolante avec une première couche de dioxyde de silicium,

revêtement d'une première couche de métal sur ladite couche de dioxyde de silicium,

revêtement de ladite première couche de métal avec une seconde couche de photorésistance,

revêtement de ladite seconde couche de photorésistance avec une seconde couche de dioxyde de silicium,

revêtement de ladite seconde couche de dioxyde de silicium avec une seconde couche de métal capable d'être attaquée par un réactif d'attaque différent de ladite première,

revêtement de ladite seconde couche de métal avec une troisième couche de métal capable d'être attaquée par un réactif d'attaque différent desdites première et seconde couches de métal,

revêtement de ladite troisième couche de métal avec une quatrième couche de métal capable d'être attaquée par un réactif d'attaque différent desdites première, seconde et troisième couches de métal,

revêtement de ladite quatrième couche de métal avec une troisième couche de photorésistance,

traitement de ladite troisième couche de photorésistance pour former de manière photolithographique une matrice de lignes transversales auxdites lignes conductrices de cathode et ensuite attaque sélective de chaque couche de matériau jusqu'à ce que des canaux séparent chacune des lignes de ladite matrice dans laquelle il y a des première et seconde structures de métal isolées les unes des autres et de la structure de cathode.

revêtement de la structure traitée avec une couche de dioxyde de silicium,

suppression de ladite couche de dioxyde de silicium et de ladite quatrième couche de métal.

2. Le procédé suivant la revendication 1 incluant en outre l'étape de pose d'une plaque d'anode parallèlement auxdites matrices d'anode, de cathode et de grille.

3. Le procédé suivant la revendication 1, dans lequel l'étape de revêtement avec une couche isolante de photorésistance est un revêtement avec une résine phénolique.

4. Le procédé suivant la revendication 1, dans lequel ledit premier métal est du chrome.

5. Le procédé suivant la revendication 1, dans lequel ledit second métal est de l'aluminium.

6. Le procédé suivant la revendication 1, dans lequel ledit troisième métal est un alliage d'aluminium et de chrome.

7. Le procédé suivant la revendication 1, dans lequel ledit quatrième métal est un alliage de titane et de tungstène.

8. Le procédé suivant la revendication 1, dans lequel lesdites couches de dioxyde de silicium ont une épaisseur d'environ 2000 Angstroems.

9. Le procédé suivant la revendication 1, dans lequel lesdites couches de photorésistance ont une épaisseur entre 3 et 5 microns.

10. Le procédé suivant la revendication 1, dans lequel l'attaque sélective inclut l'attaque desdites couches de dioxyde de silicium et desdites couches de photorésistance par attaque au plasma.

11. Le procédé suivant la revendication 1, dans lequel les étapes de revêtement avec une couche isolante de photorésistance incluent une rotation de ladite photorésistance sur ladite couche.

12. Le procédé suivant la revendication 1, dans lequel la structure d'électrode de métal représentative de la matrice de grille comprend une pluralité de lignes de grille avec chaque ligne comprenant au moins deux membres de ligne.

13. Le procédé suivant la revendication 1, dans lequel une structure de métal a des lignes parallèles aux lignes de cathode, tandis que l'autre structure de métal a des lignes transversales aux lignes de ca-

thode.

14. Un procédé pour fabriquer un afficheur électrophorétique du type ayant une matrice en X-Y pour fonctionnement de grille et de cathode, comprenant les étapes de:

dépôt d'une première couche mince d'un métal conducteur sur une plaque support en verre,

10

attaque de ladite couche pour former un motif de lignes représentatif d'une matrice de cathode en X,

dépôt d'une première couche isolante de résine photorésistante sur ladite matrice de cathode en X,

15

dépôt d'une première couche de dioxyde de silicium sur ladite première couche de résine photorésistante,

20

dépôt d'une seconde couche de métal conducteur sur ladite couche de dioxyde de silicium,

25

dépôt d'une seconde couche isolante de résine photorésistance sur ladite seconde couche de métal,

exposition de ladite seconde couche de photorésistance avec un masque de matrice de grille en Y,

30

développement de ladite photorésistance selon ledit masque de grille en Y,

35

attaque de ladite seconde couche dudit métal conducteur pour former ladite matrice de grille en Y,

40

suppression du reste de ladite seconde couche de photorésistance,

attaque de ladite couche de dioxyde de silicium avec ladite seconde couche attaquée de métal conducteur servant de masque,

45

dépôt d'une troisième couche de résine photorésistante sur ladite seconde couche attachée,

50

dépôt d'une seconde couche de dioxyde de silicium sur ladite troisième couche de photorésistance,

dépôt d'une première couche de métal d'anode sur ladite couche de dioxyde de silicium,

55

dépôt d'une seconde couche de métal d'anode

différente sur ladite première couche de métal d'anode,

dépôt d'une quatrième couche de résine photorésistante sur ladite seconde couche de métal différente,

traitement de ladite quatrième couche de photorésistance pour former de manière photolithographique une matrice d'anode de lignes parallèles à ladite matrice de grille en Y et perpendiculaires à ladite matrice de cathode en X,

attaque desdites première et seconde couches d'anode,

revêtement de ladite structure avec une couche mince de dioxyde de silicium et attaque de ladite seconde couche de métal d'anode laissant ladite première couche d'anode pour fournir une matrice additionnelle désignée comme une matrice d'anode pour ledit afficheur.

15. Le procédé suivant la revendication 14, incluant en outre les étapes de pose d'une plaque d'anode parallèlement auxdites matrices d'anode, de cathode et de grille.

16. Le procédé suivant la revendication 14, dans lequel ladite première couche mince de métal conducteur est en oxyde d'étain dopé à l'indium (ITO).

17. Le procédé suivant la revendication 14, dans lequel ladite seconde couche de métal est en chrome.

18. Le procédé suivant la revendication 14, dans lequel ladite première couche de métal d'anode est en aluminium avec ladite seconde couche de métal d'anode en chrome.

19. Le procédé suivant la revendication 14, dans lequel l'étape de dépôt d'une résine photorésistante sur ladite matrice de cathode en X tourne ladite résine sur ladite matrice de cathode en X.

20. Le procédé suivant la revendication 14, dans lequel l'étape d'attaque de ladite couche de dioxyde de silicium est une attaque au plasma de ladite couche.

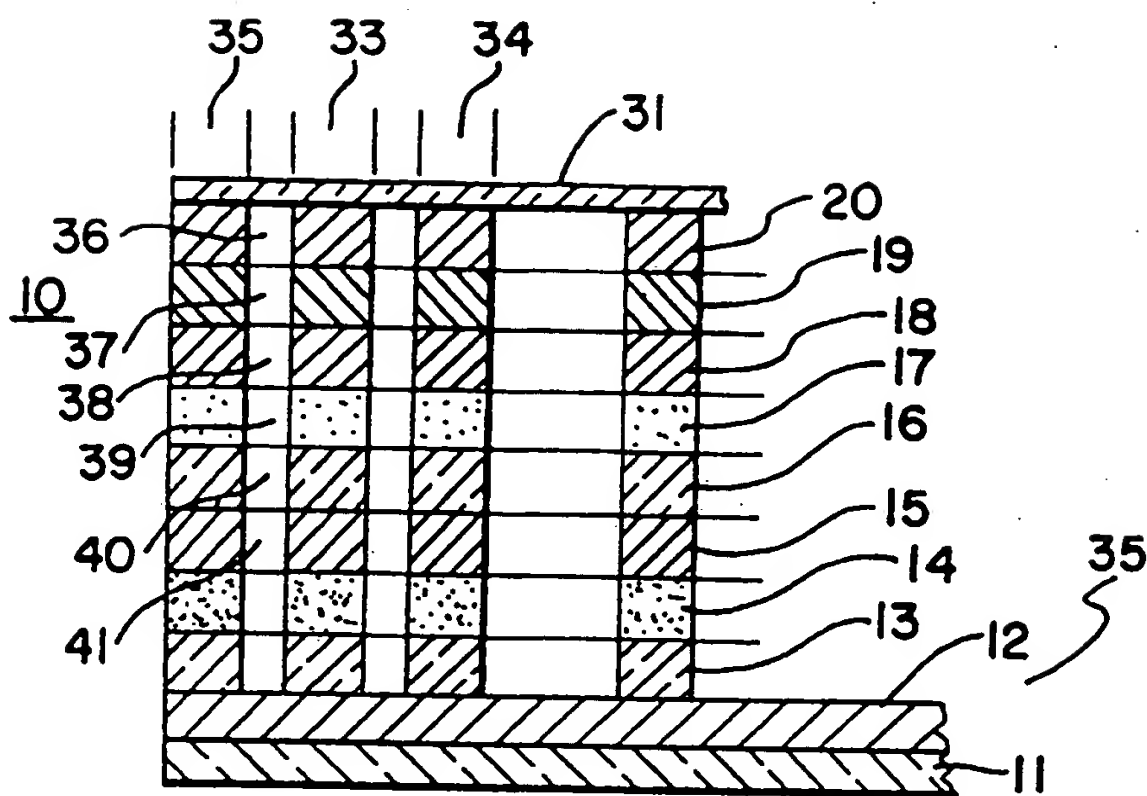


FIG. 1

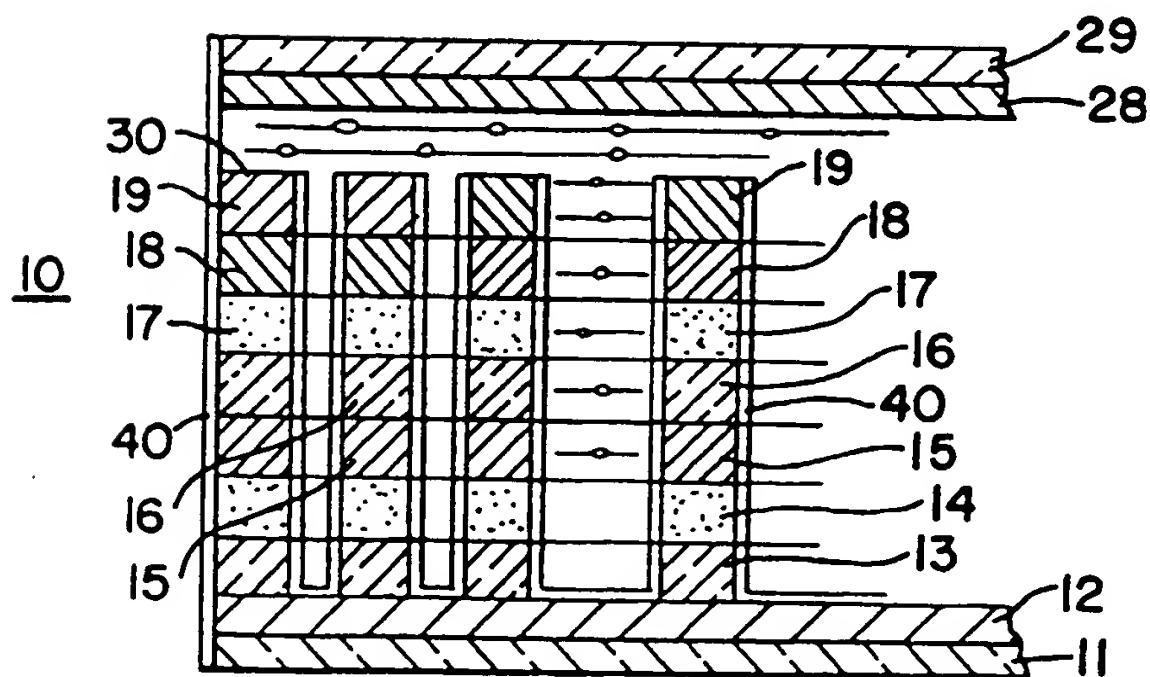


FIG. 2

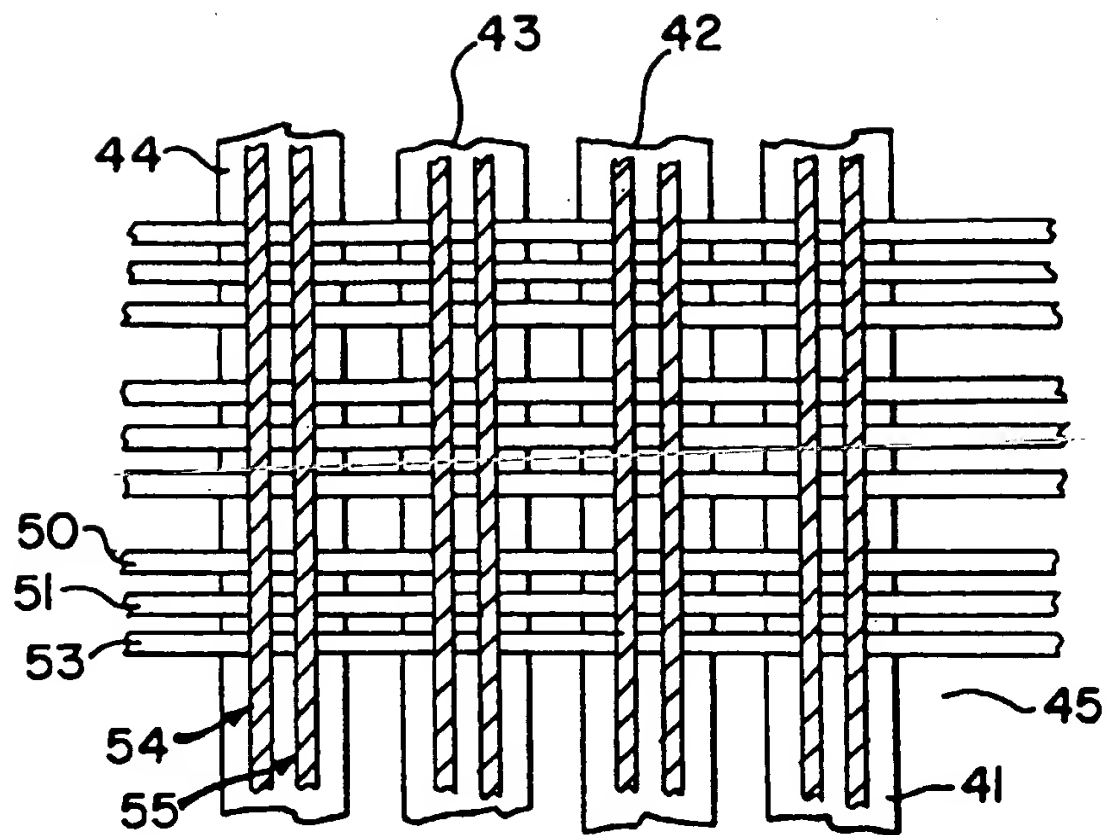


FIG. 3

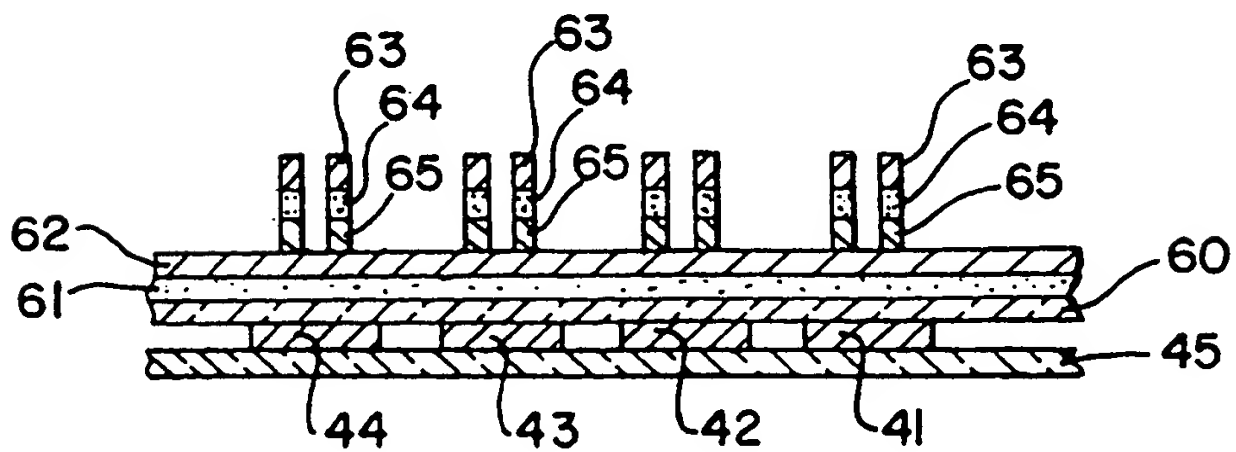


FIG. 4

